Chapter 04 Lecture Outline*

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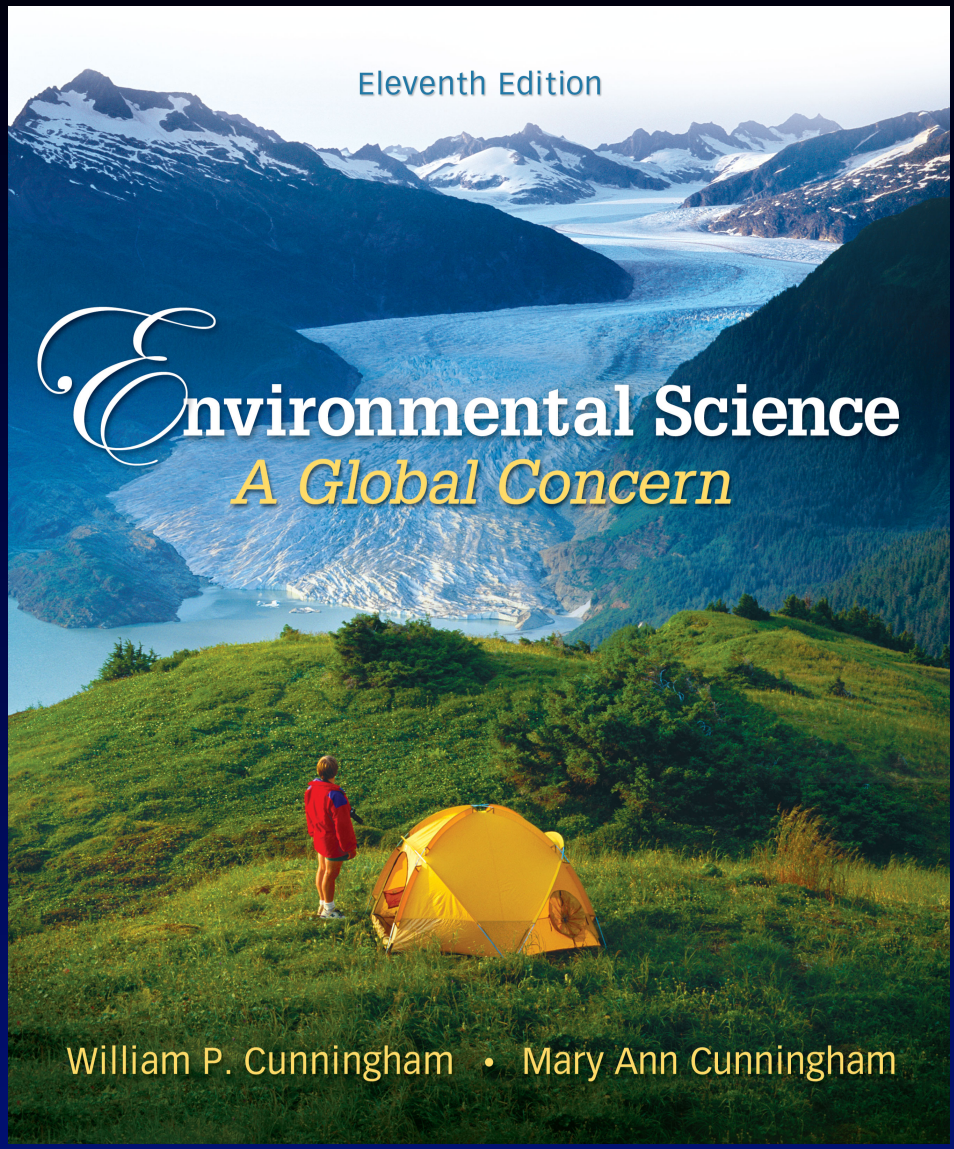

***See PowerPoint Image Slides for all figures and tables pre-inserted into PowerPoint without notes.**

Evolution, Biological Communities, and Species Interactions

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Outline

- Evolution and Natural Selection
- Ecological Niche
- Species Interactions
- Community Properties
- Communities Change Over Time

Adaptation

- Why do some species live in one place but not another?
  - Adaptation - the acquisition of traits that allow a species to survive in its environment
- Adaptation is explained by Charles Darwin's theory of evolution by natural selection.

Evolution

- A trait must be inherited (genetic) for it to evolve.
- Individuals with traits that make them suited to a particular environment survive and reproduce at a greater rate in that environment than individuals with less suitable traits.
- Over time the proportion of genes in the population for favorable traits increases. The proportion of genes for unsuitable traits declines. Thus, adaptation occurs.

Natural Selection

- The process whereby individuals suited to a particular environment pass on more of their genes to the next generation is called natural selection.

- Where do the differences in the genes within individuals come from?
  - Mutation - changes in DNA sequence that occur by chance (random mistakes in DNA replication, exposure to radiation, etc.)

Selection Pressures

- It is the environment that gives certain mutations an advantage under those particular conditions and causes other variants to be disadvantaged. The environment exerts selection pressures.

- No variation is inherently good or bad. As environments change, the trait being selected for will change. A trait that was once selected against can be selected for if the environment changes.

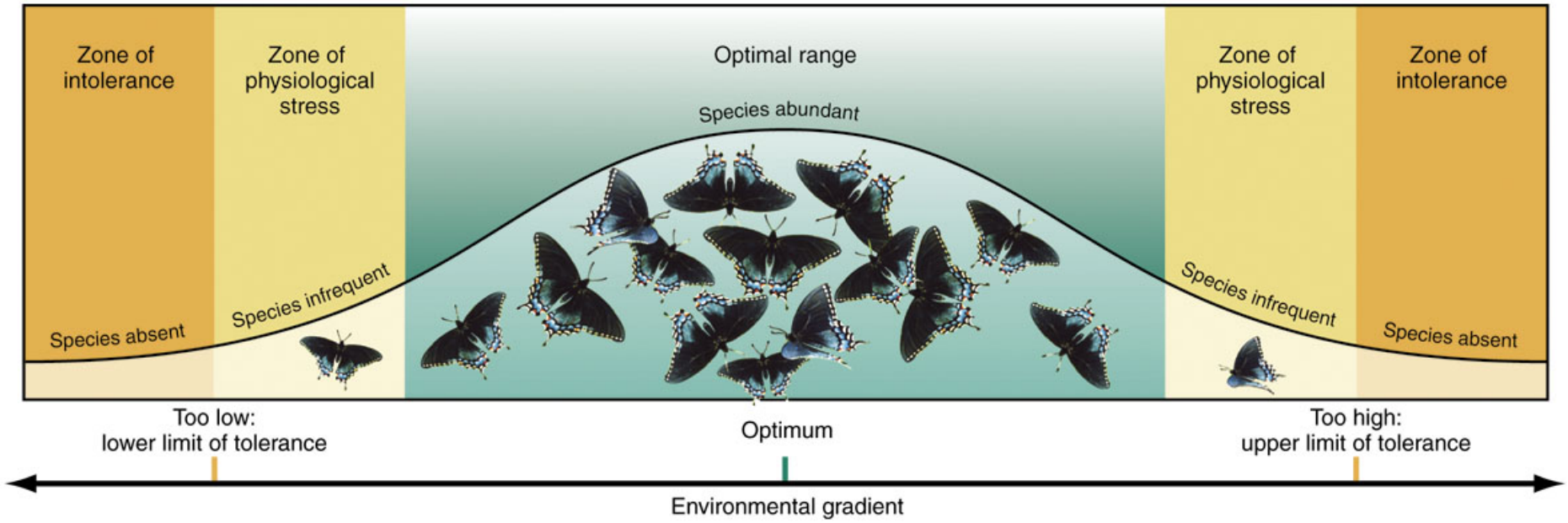
Limitations on Where an Organism Can Live

- Environmental factors that determine where an organism can live include:
  - Physiological stress due to inappropriate levels of moisture, temperature, pH, etc.
  - Competition with other species
  - Predation, parasitism, disease
  - Chance - individuals move to a new and suitable location by chance e.g. organism moved to a different beach after a storm

Critical Limits

- Von Liebig proposed the single factor in shortest supply relative to demand is the critical factor in species distribution.
  - Shelford later expanded by stating that each environmental factor has both minimum and maximum levels, tolerance limits, beyond which a particular species cannot survive or is unable to reproduce. The factor closest to the limits is the critical factor that determines where an organism can live.

Tolerance Limits



Critical Limits

- For some species, the interaction of several factors, rather than a single limiting factor, determines biogeographical distribution.
  - Tolerance limits may affect the distribution of young differently than adults.

- Species requirements and tolerances can also be used as useful indicators of specific environmental characteristics. Example: Trout require clean, well oxygenated water so their disappearance from a stream may indicate that it is being polluted.

Habitat and Ecological Niches

- Habitat - the place or set of environmental conditions in which a particular organism lives

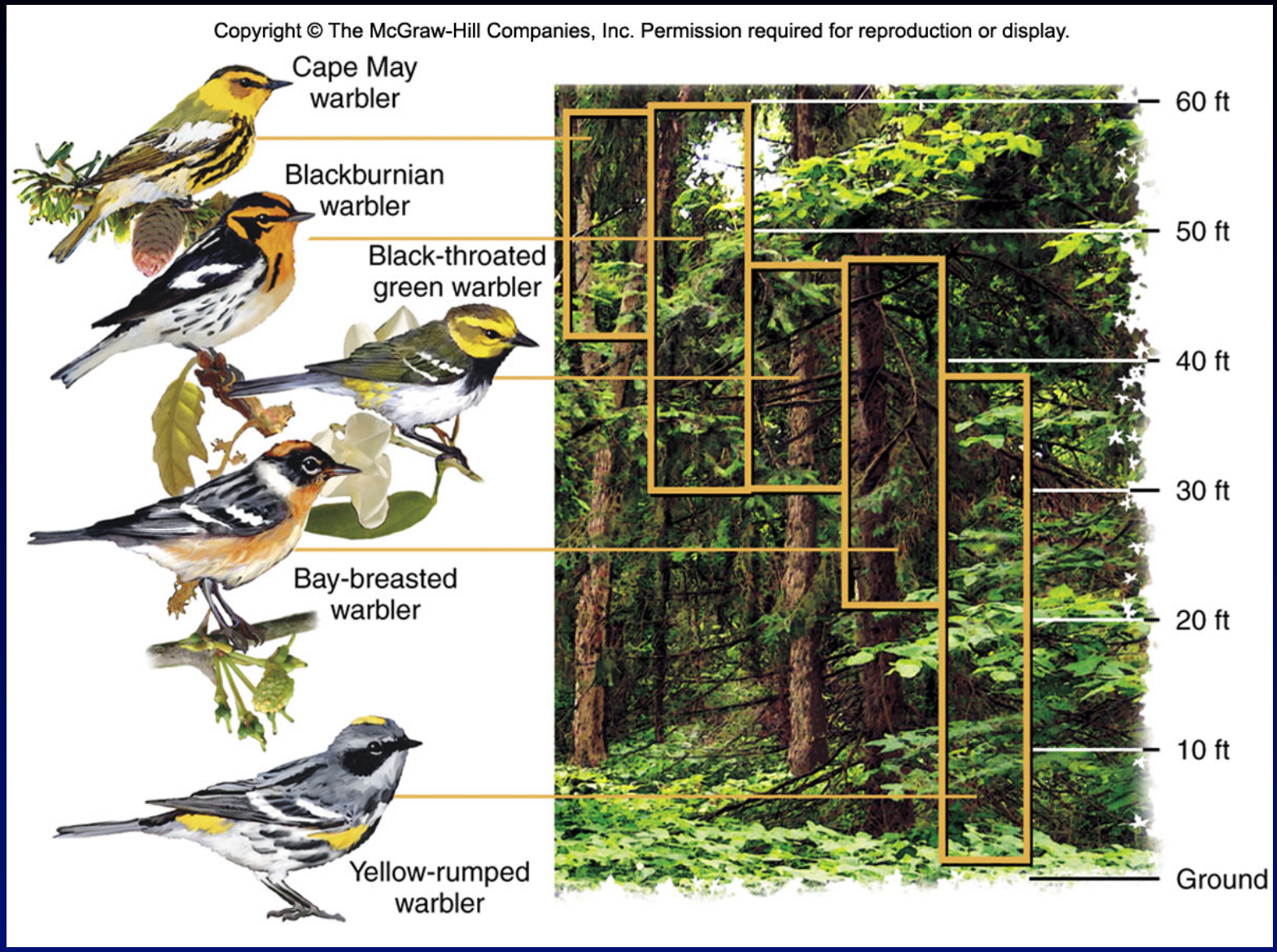
- Ecological niche - describes either the role played by a species in a biological community or the total set of environmental factors that determine a species distribution
  - Generalist - has a broad niche (rat)
  - Specialist - has a narrow niche (panda)

Competitive Exclusion

- Gause proposed the competitive exclusion principle which states that no two species can occupy the same ecological niche at the same time. The one that is more efficient at using resources will exclude the other.

- Resource partitioning - species co-exist in a habitat by utilizing different parts of a single resource. Example: Birds eat insects during the day and bats eat insects at night.

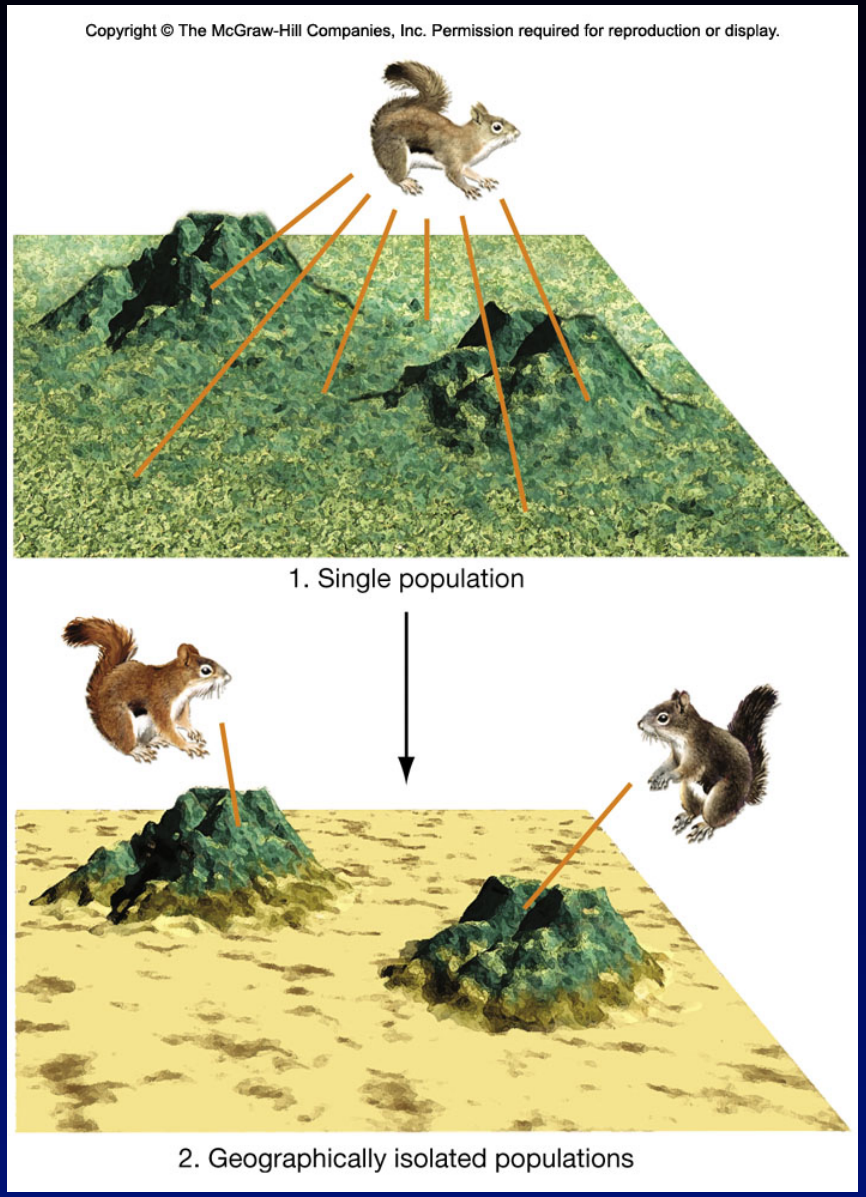
Resource Partitioning



Speciation

- Speciation - the development of a new species
  - Can occur due to geographic isolation whereby a sub-population becomes separated from the main population and can no longer share genes with it. The new population evolves independently of the first, creating a new species. This is termed allopatric speciation.

Allopatric Speciation



Speciation

- In sympatric speciation, organisms continue to live in the same place but become isolated by some other means.

- Example: Some fern species have doubled the number of chromosomes they have. This prevents them from breeding with the population from which they originally came and effectively creates a new species.

The Populations Diverge

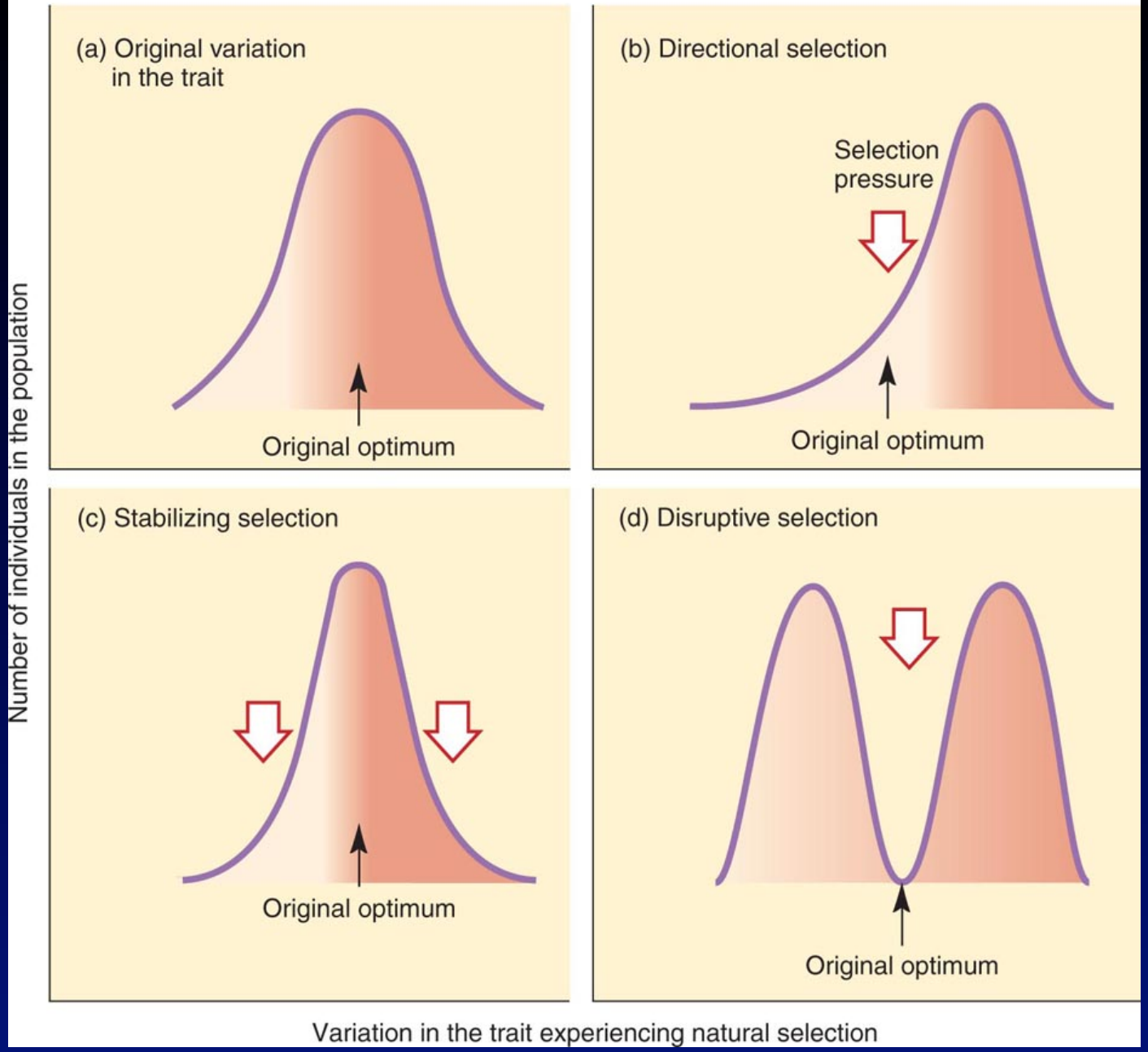
- Once isolation occurs, the two populations begin to diverge due to:
  - Genetic drift - chance events that cause genes to be lost from a population
  - Selection pressure - the selection pressures on the two populations are different

Types of Selection

- Directional selection - one trait is being favored and the other is being eliminated so the population shifts toward one trait

- Stabilizing selection - range of a trait is narrowed

- Disruptive selection - traits diverge toward the two extremes



Evolution is Still at Work

- In the Galapagos Islands, scientists have documented a change in the shape of finch beaks in just the past twenty years. When plants that made large seeds died due to a drought and only small seeds were available as food, the birds who had a beak shape suitable for eating small seeds survived and reproduced, and birds with beaks suited to eating large seeds died out.

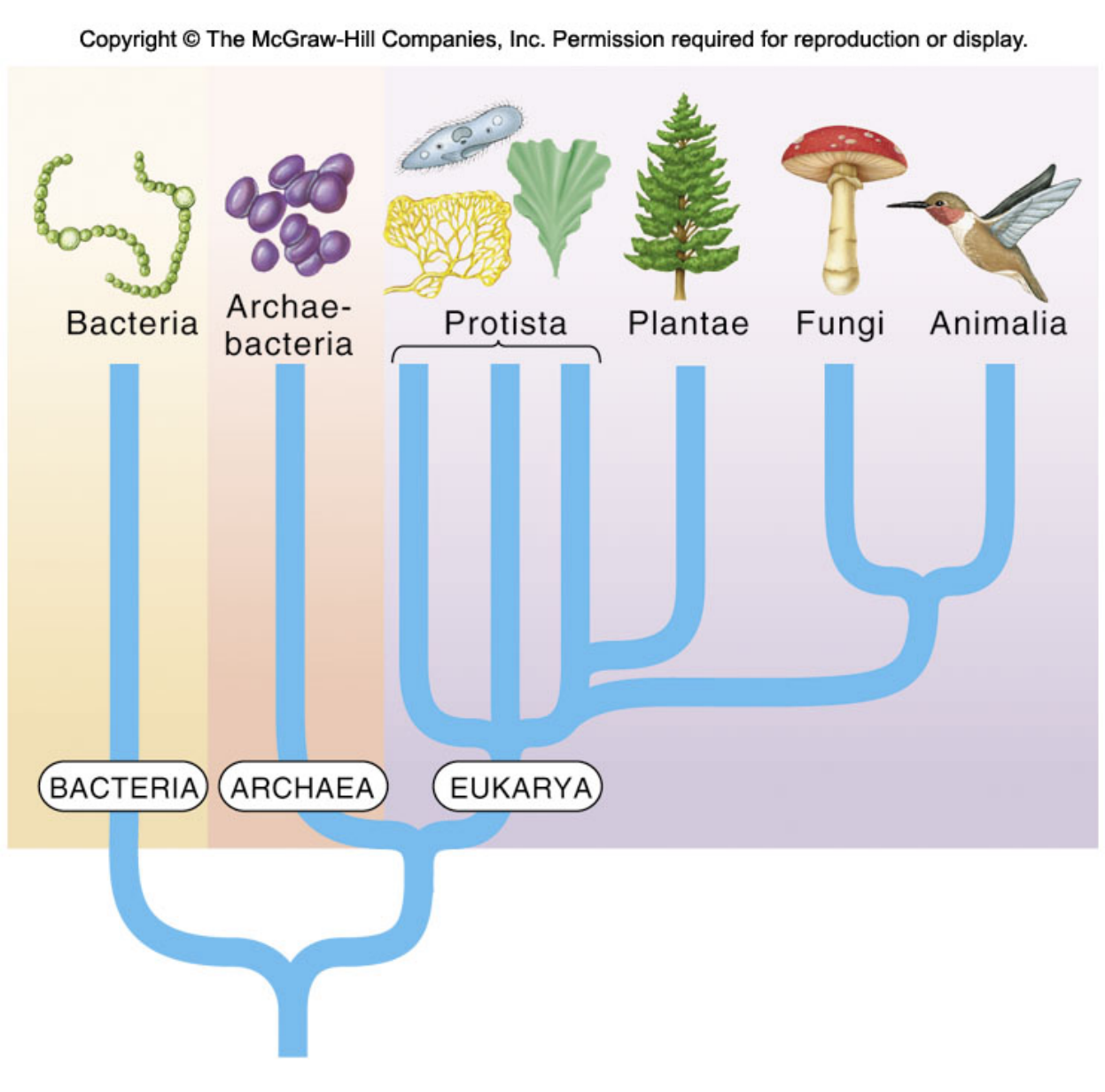
Taxonomy

- Taxonomy is the study of organisms and their evolutionary relationships. It traces how organisms have descended from common ancestors.

- Scientists assign every organism a genus and species name (a binomial) so that everyone can refer to a particular organism accurately.

- Organisms are then organized into higher taxonomic categories such as kingdoms, etc.

The Six Kingdoms



Species Interactions

- Intraspecific competition - competition among members of the same species
  - Competition is reduced if:
    - young disperse
    - animal defends a territory
    - adults and juveniles occupy different niches

- Interspecific competition - competition between members of different species

Predation

- A predator is any organism that feeds directly on another organism, whether or not this kills the prey. Example: a parasite feeds on an organism but does not kill it.

- Predator-mediated competition - one species may be the best competitor in a given location, but predators may reduce its abundance and allow the weaker competitor to increase its numbers

Adaptations to Avoid Predation

- As predators become more efficient, the prey evolve defenses (thorns, toxic chemicals, etc.).
- Over time predator and prey evolve in response to one another (coevolution).
- Species with chemical defenses often evolve warning coloration.
  - Harmless species mimic the warning coloration of harmful species to gain protection (Batesian mimicry).
  - Two harmful species evolve to look alike (Mullerian mimicry).

Batesian Mimicry

(a) © Edward S. Ross

(b) © Edward S. Ross

Symbiosis

- In symbiosis two or more species live intimately together with their fates linked.
- Mutualism - both organisms benefit from their association e.g. a fungus and an alga combine to make a lichen
- Commensalism - one species benefits while the other neither benefits nor is harmed. Example: You plant a yard and a robin comes.
- Parasitism, a form of predation, is also sometimes considered a symbiosis because of the dependency of the parasite on its host.

(a) Lichen on a rock

© William P. Cunningham

(b) Oxpecker and impala

PhotoDisc Royalty Free

(c) Bromeliad

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Keystone Species

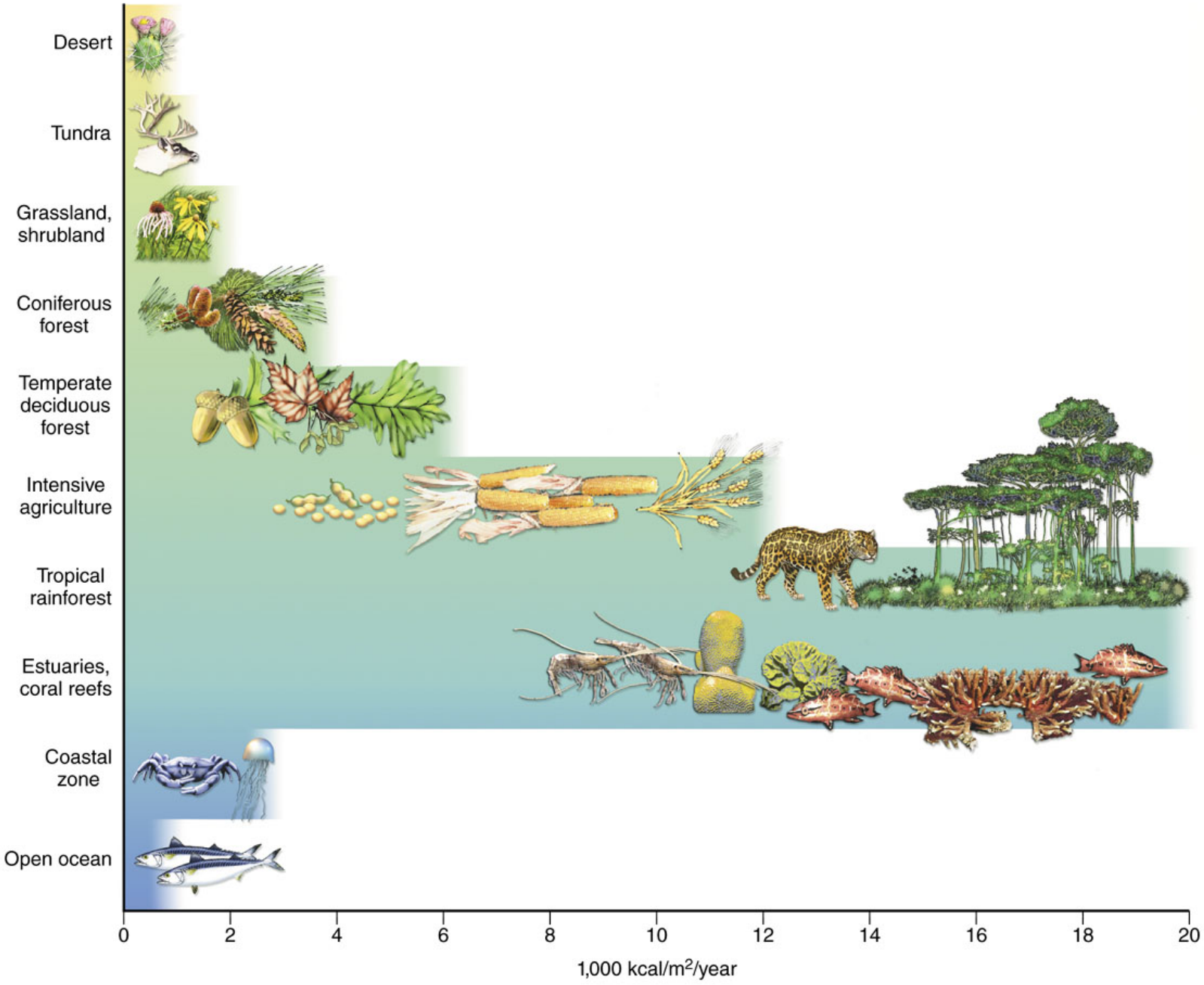
- A keystone species plays a critical role in a biological community that is out of proportion to its abundance.

- Example: In the tropics, figs bear fruit year around. In the dry season, this is the only food available for many species. If figs were removed from the forest, many fruit-eating animals would disappear and this in turn would affect many other plants that depend upon them for pollination. So, the fig is key to the survival of the community.

Community Properties

- Primary Productivity - rate of biomass production. Used as an indication of the rate of solar energy conversion to chemical energy
  - Net Primary Productivity - energy left after respiration

- Tropical forests, coral reefs, and estuaries have some of the highest levels of productivity.



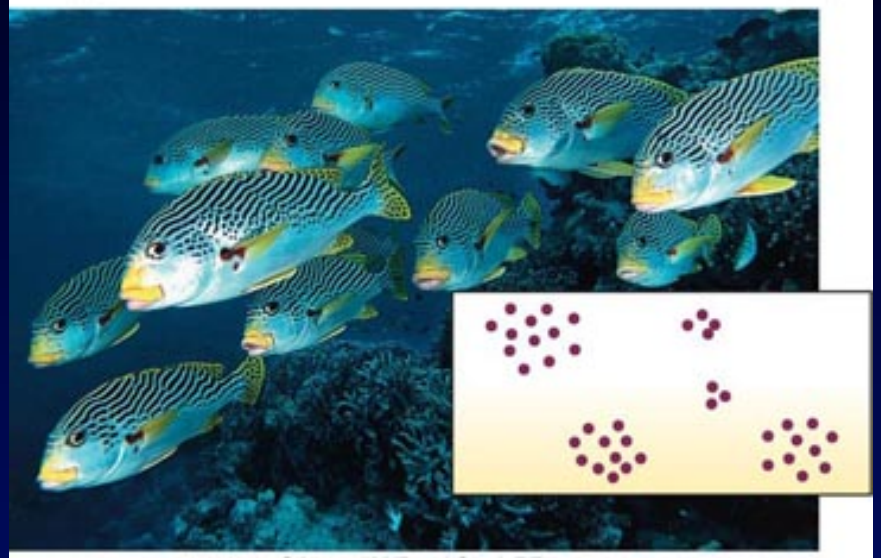
Abundance and Diversity

- Abundance - total number of organisms in a community
- Diversity - number of different species, ecological niches, or genetic variation
  - Abundance of a particular species is often inversely related to community diversity.
  - As a general rule, diversity decreases and abundance within species increases when moving from the equator to the poles.

Community Structure

- Ecological structure - patterns of spatial distribution of individuals and populations within a community
  - random distribution
  - clustered/clumped distribution - for protection, mutual assistance, reproduction, access to resources
  - uniform distribution - often the result of competition

- Distribution can be vertical as well as horizontal.



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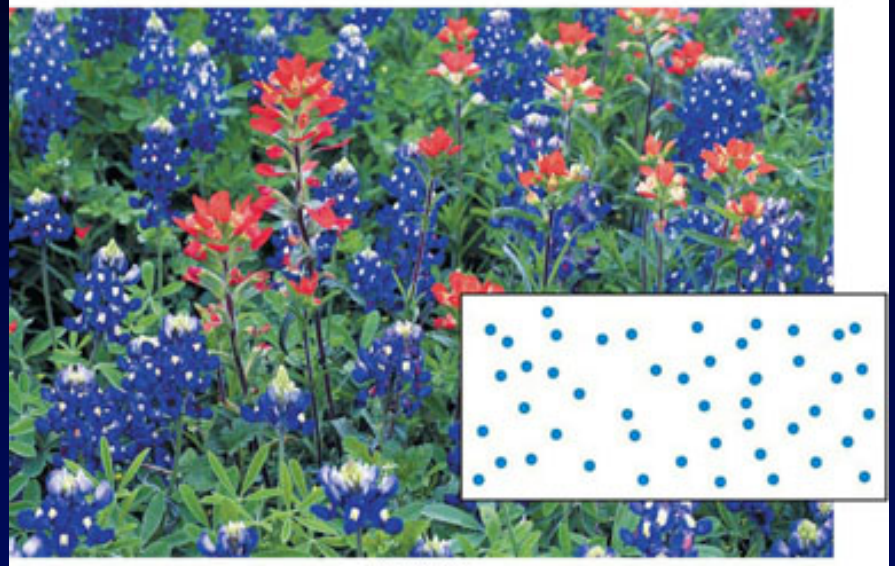

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Complexity and Connectedness

- Complexity - number of species at each trophic level and the number of trophic levels in a community
  - Diverse community may not be complex if all species are clustered in a few trophic levels.
  - Highly interconnected community may have many trophic levels, some of which can be compartmentalized.

Tropical Rainforests: Diverse and Complex

Resilience and Stability

- Constancy (Lack of fluctuation in composition or function)
- Inertia (Resistance to perturbation)
- Renewal (Ability to repair damage after a disturbance)
  - MacArthur proposed that complex, interconnected communities would be more stable and resilient in the face of disturbance.
    - Some studies have supported this idea while others have not.

Edges and Boundaries

- Edge Effects - important aspect of community structure is the boundary between one habitat and others

- Ecotones - boundaries between adjacent communities
  - Sharp boundaries - closed communities
  - Indistinct boundaries - open communities

Ecotones

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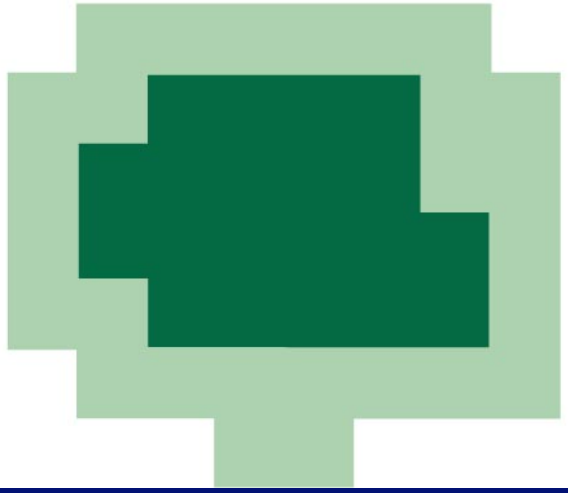
Edge Effects

Total area: 47 ha

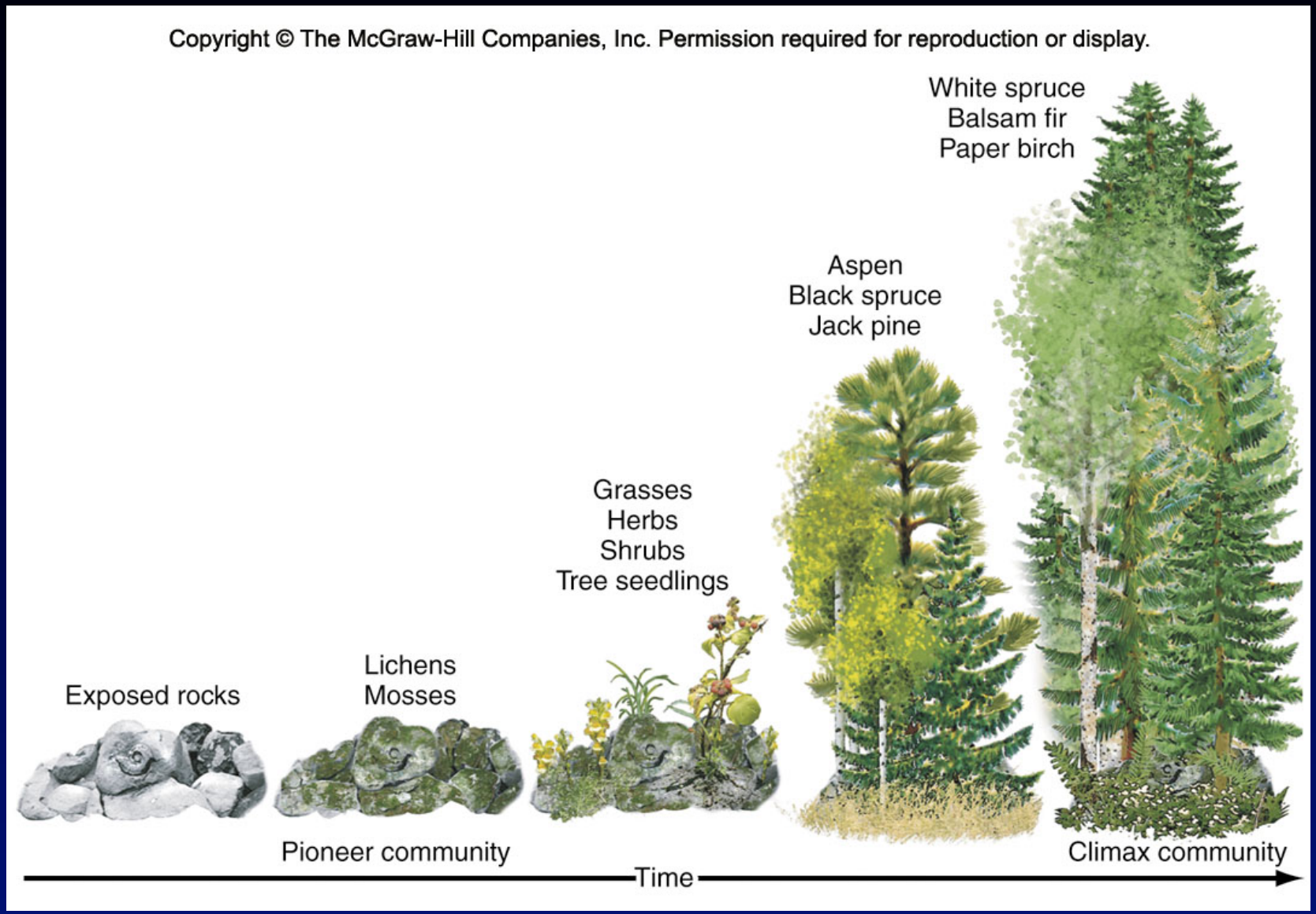
Core area: 0 ha



Communities in Transition

- Ecological Succession
  - Primary Succession - A community begins to develop on a site previously unoccupied by living organisms. Example: A lava flow creates a new land area that is colonized. The first colonists are termed pioneer species.
  - Secondary Succession - an existing community is disrupted and a new one subsequently develops at the site
  - Climax community - community that develops last and remains the longest

Primary Succession



Disturbances

- A disturbance is any force that disrupts established patterns of species diversity and abundance, community structure, or community properties e.g. storms, fires, logging.
- Disturbance tends to disrupt the superior competitors the most and allows less competitive species to persist.
- Some landscapes never reach a climax community because they are characterized by periodic disturbances (such as wildfires) and are made up of disturbance-adapted species.

Introduced Species and Community Change

- If introduced species prey upon or compete more successfully than native populations, the nature of the community may be altered.
  - Introduction of rats, cats, goats and pigs where European sailing ships landed
  - Introduction of exotic species to solve problems caused by previous introductions
    - Mongoose and rats in Caribbean

Mongoose

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